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THE PALEONTOLOGICAL EVIDENCE FOR THE TRANSMISSION OF ACQUIRED CHARACTERS.[1]

MUCH of the evidence brought forward in France and Germany in support of the transmission of acquired characters, which has been so ably criticised in Weismann's recent essays, is of a very different order from that forming the main position of the so-called Neo-Lamarckians in America. It is true that most American zoölogists, somewhat upon Semper's lines, have supported the theory of the direct action of environment, always assuming, however, the question of transmission. But Cope, the able if somewhat extreme advocate of these views, with Hyatt, Ryder, Brooks, Dall, and others, holding that "the survival of the fittest" is now amply demonstrated, submit that, in our present need of an explanation of the origin of the fittest, the principle of selection is inadequate, and have brought forward and discussed the evidence for the inherited modifications produced by re-actions in the organism itself: in other words, the indirect action of environment. The supposed arguments from pathology and mutilations have not been considered at all: these would involve the immediate inheritance of characters impressed upon the organism and not springing from internal re-actions, and thus differ, both in the element of time and in their essential principle, from the above. As the selection principle is allowed all that Darwin claimed for it in his later writings, this school stands for Lamarckism *plus* — not *versus* — Darwinism, as Lankester has recently put it. There is naturally a diversity of opinion as to how far each of these principles is operative, not that they conflict.

The following views are adopted from those held by Cope and others, so far as they conform to my own observations and apply to the class of variations which come within the range of paleontological evidence. In the life of the individual, adaptation is increased by local and general metatrophic changes, of necessity correlated, which take place most rapidly in the regions of least perfect adaptation, since here the re-actions are greatest. The main trend of variation is determined by the slow transmission, not of the full increase of adaptation, but of the disposition to adaptive atrophy or hypertrophy at certain points. The variations thus transmitted are accumulated by the selection of the individuals in which they are most marked, and by the extinction of inadaptive varieties or species. Selection is thus of the *ensemble* of new and modified characters. Finally, there is sufficient paleontological and morphological evidence that acquired characters, in the above limited sense, are transmitted.

In the present state of discussion, every thing turns upon the last proposition. While we freely admit that transmission has been generally assumed, a mass of direct evidence for this assumption has nevertheless been accumulating, chiefly in the field of paleontology. This has evidently not reached Professor Weismann, for no one could show a fairer controversial spirit, when he states repeatedly, "'Not a single fact hitherto brought forward can be accepted as proof of the assumption.'' It is, of course, possible for a number of writers to fall together into a false line of reasoning from certain facts. It must, however, be pointed out that we are now deciding between two alternatives only; viz., pure selection, and selection *plus* transmission.

The distinctive feature of our rich paleontological evidence is that it covers the entire pedigree of variations: we are present not only at, but before birth, so to speak. Among many examples, I shall select here only a single illustration from the mammalian series,— the evolution of the molar teeth associated with the peculiar evolution of the feet in the horses. The feet, starting with plantigrade bear-like forms, present a continuous series of re-adjustments of the twenty-six original elements to digitigradism which furnish proof sufficient to the Lamarckian. But, as selectionists would explain this complex development and reduction by panmixia and the selection of favorable fortuitous correlations of elements already present, the teeth render us more direct service in this discussion, since they furnish not only the most intricate correlations and re-adjustments, but the complete history of the addition of a number of entirely new elements,— the rise of useful structures from their minute embryonic, apparently useless, condition, the most vulnerable point in the pure selection theory. Here are opportunities we have never enjoyed before in the study of the variation problem.

The first undoubted ancestor of the horse is *Hyracotherium*. Let us look back into the early history of its multicuspid upper molars, every step of which is now known. Upon the probability that mammalian teeth were developed from the reptilian type, Cope predicted in 1871 that the first accessory cusps would be found on the anterior and posterior slopes of a single cone; i.e., at the points of interference of an isognathous series in closing the jaws. Much later I showed that precisely this condition is filled in the unique molars of the Upper Triassic *Dromotherium*. These, with the main cusp, form the three elements of the tritubercular crown. Passing by several well-known stages, we reach one in which the heel of the lower molars intersects, and, by wearing, produces depressions in the transverse ridges of the upper molars. At these points are developed the intermediate tubercles which play so important a *rôle* in the history of the ungulate molars. So, without a doubt, every one of the five main component cusps superadded to the original cones is first prophesied by a point of extreme wear, replaced by a minute tubercle, and grows into a cusp. The most worn teeth, i.e., the first true molars, are those in which these processes take place most rapidly. We compare hundreds of specimens of related

[1] This article is an informal reply to the position taken by Professor Weismann in his essays upon heredity. I have borrowed freely from the materials of Cope, Ryder, and others, without thinking it necessary to give acknowledgment in each case. [Reprinted from Nature.]

species. Everywhere we find the same variations at the same stages, differing only in size, never in position. We extend the comparison to a widely separate phylum, and find the same pattern in a similar process of evolution. Excepting in two or three side-lines, the teeth of all the *Mammalia* have passed through closely parallel early stages of evolution, enabling us to formulate a law: The new main elements of the crown make their appearance at the first points of contact and chief points of wear of the teeth in preceding periods. Whatever may be true of spontaneous variations in other parts of the organism, these new cusps arise in the perfectly definite lines of growth. Now, upon the hypothesis that the modifications induced in the organism by use and disuse have no directive influence upon variations, all these instances of sequence must be considered coincidences. If there is no causal relationship, what other meaning can this sequence have? Even if useful new adjustments of elements already existing may arise independently of use, why should the origin of new elements conform to this law? Granting the possibility that the struggle for existence is so intense that a minute new cusp will be selected if it happens to arise at the right point, where are the non-selected new elements, the experimental failures of nature? We do not find them. Paleontology has, indeed, nothing to say upon individual selection, but chapters upon unsuccessful species and genera. Here is a practical confirmation of many of the most forcible theoretical objections which have been urged against the selection theory.

Now, after observing these principles operating in the teeth, look at the question enlarged by the evolution of parallel species of the horse series in America and Europe, and add to the development of the teeth what is observed in progress in the feet. Here is the problem of correlation in a stronger form even than that presented by Spencer and Romanes. To vary the mode of statement, what must be assumed in the strict application of the selection theory? (*a*) That variations in the lower molars correlated with coincident variations of reversed patterns in the upper molars, these with metamorphoses in the premolars and pocketing of the incisor enamel; (*b*) all new elements and forms, at first so minute as to be barely visible, immediately selected and accumulated; (*c*) in the same individuals, favorable variations in the proportions of the digits, involving re-adjustments in the entire limbs and skeleton, all coincident with those in the teeth; (*d*) finally, all the above new variations, correlations, and re-adjustments not found in the hereditary germ-plasm of one period, but arising fortuitously by the union of different strains, observed to occur simultaneously and to be selected at the same rate in the species of the Rocky Mountains, the Thames valley, and Switzerland. These assumptions, if any thing, are understated. Any one of them seems to introduce the element of the inconstant; whereas in the marvellous parallelism, even to minute teeth-markings and osteological characters, in all the widely distributed forms between *Hyracotherium* and *Equus*, the most striking feature is the constant. Viewed as a whole, this evolution is one of uniform and uninterrupted progression, taking place simultaneously in all the details of structure over great areas. So nearly does race adaptation seem to conform to the laws of progressive adaptation in the individual, that, endowing the teeth with the power of immediate re-active growth like that of the skeleton, we can conceive the transformation of a single individual from the eocene five-toed bunodont into the modern horse.

The special application of the Lamarckian theory to the evolution of the teeth is not without its difficulties, some of which have been pointed out to me by Mr. E. B. Poulton. To the objection that the teeth are formed before piercing the gum, and the wear produces a loss of tissue, it may be replied that it is not the growth, but the re-action which produces it, which is supposed to be transmitted. Again, this is said to prove too much. Why is the growth of these cusps not continuous? This may be met in several ways: first, in the organism itself these re-actions are least in the best adapted structures, a proposition which is more readily demonstrated in the feet than in the teeth (moreover, since the resulting growth never exceeds the uses of the individual, there is a natural limit to its transmission); second, the growth of the molars is limited by the nutritive supply (we observe one tooth or part growing at the expense of another); third, in some phyla we do observe growth which appears to lead to inadaptation, and is followed by extinction. In one instance we observe the recession of one cusp taking place *pari passu* with the development of the one opposed to it. These and many more general objections may be removed later; but they are of such force, that, even granting our own premises, we cannot now claim to offer a perfectly satisfactory explanation of all the facts.

The evidence in this field for, is still much stronger than that against, this theory. To sum up: the new variations in the skeleton and teeth of the fossil series are observed to have a definite direction; in seeking an explanation of this direction, we observe that it universally conforms to the re-actions produced in the individual by the laws of growth; we infer that these re-actions are transmitted. If the individual is the mere pendant of a chain (Galton), or upshoot from the continuous root of ancestral plasm (Weismann), we are left at present with no explanation of this well-observed definite direction. But how can this transmission take place? If, from the evident necessity of a working theory of heredity, the *onus probandi* falls upon the Lamarckian,— if it be demonstrated that this transmission does not take place,— then we are driven to the necessity of postulating some as yet unknown factor in evolution to explain these purposive or directive laws in variation, for, in this field at least, the old view of the random introduction and selection of new characters must be abandoned, not only upon theoretical grounds, but upon actual observation.

Reading between the lines of Weismann's deeply interesting essays, it is evident that he himself is coming to this conclusion.

HENRY FAIRFIELD OSBORN.

AMERICAN ARCHIVES IN SEVILLE.[1]

IF I could meet the historical students of the Johns Hopkins University or the members of the Maryland Historical Society, I am quite sure, that with the aid of a few photographs which I can find here, and with the aid of a few books to which, as a hurried traveller, I cannot here find access, their interest would be quickly excited in an account of the celebrated collection of papers pertaining to early American history which I have just visited for the second time. I am not so sure that by means of a letter I can convey the same impression; nevertheless I will try.

The Alcazar, which is to be compared with, if it does not equal, the Alhambra as a Moorish palace; the Giralda, a magnificent bell-tower, noble in size, proportions, and details, and famous as an observatory in the days of Moorish supremacy; and the Cathedral, which contains a few of the most celebrated works of Murillo,—form a group of buildings which has given renown to Seville, and has drawn the admiring gaze of architects and poets and historians from every part of the civilized world.

Under the shadow of these world-famous monuments are two edifices which, in comparison with the three greater structures, hardly arrest the notice of the sight-seeker, though they are buildings which would be noteworthy for their age and dignity in any American city. One of these contains the Columbian Library, founded by Fernando Columbus, son of the great discoverer; and the other contains original papers which pertain to the Spanish discoveries in the New World. It is of the second of these remarkable and world-famous collections that I now propose to write.

Casa Lonja is the name of the building in which are kept "The Archives of the Indias," the title by which Spain has designated from the earliest days until now the papers pertaining to her American discoveries and possessions. For a long period the authorities of this country refused to accept the name "America," and "only yielded to the majority," as a Spanish writer informs us, "when resistance was useless."

[1] Letter from President D. C. Gilman, in the Baltimore Sun of Dec. 31, 1889, written from Seville, Spain, under date of Dec. 12.